The effect of nano compounds on the physiological characteristics of wheat seedlings

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The effect of nano compounds of copper, titanium, iron and aluminum oxides on germination energy, germination, growth and development, the content of photosynthetic pigments, the activity of photosystems of wheat seedlings was studied. The object of the research was the seedlings of soft wheat plants (*Triticum aestivum* L.). The seeds of the experimental plants treated with powders of nano compounds CuO, Fe_2O_3, ZnO, Al_2O_3, and TiO_2, sown in Petri dishes and in the pots with soil. The germination energy and germination of seeds, the content of chlorophyll a and b, carotenoids, the activity of photosystem 2 in sprouts have been determined. Nanoparticles of TiO_2, ZnO and Fe_2O_3 had a positive effect on seed germination and accelerated the growth of wheat seedlings. ZnO and Fe_2O_3 nanoparticles also positively influenced the activity of photosystem 2, where water photooxidation occurs with the release of hydrogen protons and molecular oxygen.

Keywords: *Wheat, nano compounds, germination, growth of seedlings, photosystem 2*

INTRODUCTION

Currently, nanoparticles are widely used in many sectors of agriculture. It well known that when micronutrients are added in the form of their water-soluble salts, most of them are absorbed by soil colloids and are difficult to absorb by plant roots. The accumulation of these substances in the soil solution leads to environmental pollution. Nanoparticles are distinguishing by unusual physicochemical properties, especially by their action on living organisms (Yurin, Molchan, 2015). Due to their microscopic sizes, nanoparticles can easily enter through biological membranes, accumulate in the internal environment, and accelerate the activity of metabolic processes in cells. However, it should be noted that at high doses, nanoparticles can accumulate in plants and can subsequently enter the human body (Torre-Roche, 2013; Zhu et al., 2008; Morqalev, 2010). According to some authors, silver nanoparticles at low concentrations can enhance the germination energy and seed germination, growth and development, respiration rate and the activity of enzyme systems (Kuamry et al.,2012; Salama, 2012; Omelchenko et al.. 2014; Yurkova et al., 2014). It noted that silver nanoparticles mainly accumulate in the roots of plants. It shown in works with TiO_2, Al_2O_3, Fe_3O_4 nanoparticles that these nanoparticles can have different effects depending on the concentration (Fedorenko et al., 2011; Astafurova, 2011). In these experiments, iron nanopowders at low concentrations increased the yield and grain quality of cereals. In the work (Yeqorov, 2008), the soaking of seeds with titanium, aluminum, and iron nanoparticles did not affect seed germination and plant growth. It was assumed (Kovalenko, et al., 2006) that in the process of growth and development, plants can use the surface energy of nanoparticles coming from outside, which can affect the functions of the molecular structures of the cell. It follows from the foregoing that the results of work carried out with nanoparticles are contradictory, and further studies are advisable in this direction.

The objective of this work was to study the effect of copper, titanium, iron, and aluminum nanoparticles on germination energy, germination, growth and development, the content of photosynthetic pigments, the activity of plant photosystems and antioxidant enzymes.

MATERIALS AND METHODS

The object of the study was seedlings of bread wheat (*Triticum aestivum* L.). The seeds of the experimental plants treated with powders of CuO, Fe_2O_3, ZnO, Al_2O_3 , and TiO_2, nanoparticles. Then the seeds sown in Petri dishes and in vegetation vessels with soil. The germination energy and seed germination were determined. Plant growth, the content of chlorophyll A and B, carotenoids, the activity of photosystem 2 and the enzyme superoxide dismutase were determined. The contain of chlorophyll and carotenoids in leaves was determined on SF-26 spectrophotometer by absorption at wavelengths of 665, 649 and 440 nm, the number of pigments was calculated according to the Vernon method (Shlyk, 1971). The activity of photosystem 2 was determined using a PAM device (Photosynthesis analyzer, German. Static data processing performed using the program "Statistics for windows".

RESULTS AND DISCUSSION

When determining the energy of germination and germination of seeds, it turned out that nanoparticles have different effects on these indicators (Table 1). As can be seen from table 1, the nanoparticles of TiO_2, ZnO and Fe_2O_3 have a positive effect on the germination energy and seed germination. These nanoparticles also accelerated the growth of wheat seedlings and activity of PS 2 (F_v / F_m).

When determining the content of chlorophyll a and b, it turned out that nanoparticles ZnO and Fe_2O_3 have a positive effect on the biosynthesis of these pigments (Table 2).

ZnO and Fe_2O_3 nanoparticles also had a positive effect on the activity of photosystem 2, where photooxidation of water occurs with the release of hydrogen and molecular oxygen protons. The data obtained by us are in accordance with the data obtained in the work of Yegorov and colleagues (Yeqorov, 2008; Kovalenko et al., 2006). In this work, shown that pre-sowing treatment of plant seeds with iron nanopowders at low seed concentrations positively affects the germination energy. However, an increase in concentration by an order of magnitude leads to a suppression of their growth. When studying the effect of TiO_2 and Al_2O_3 particles on the growth of beans, wheat, and amaranth plants, revealed that plant growth slows down under the influence of these particles (Astafurova, 2011). Studies on the effect of iron nanopowder on the growth, development, drought tolerance and productivity of corn, wheat and sunflower showed that the yield of these crops increases on average by 15-20%.

Table 1. The effect of nano compounds on seed germination and morphophysiological parameters of wheat seedlings

Options	Germination energy, %	Germination, %	Seedling growth (sm)		F_v / F_m
			14 day	19 day	
Control	70	90	3.5±0,2	11.0±0.1	0.8
CuO	70	80	4.5±0,3	12.0±0,3	0.6
$Ti0_2$	85	90	6.5±0,5	14.0±0,5	0.7
ZnO	90	100	6.5±0.3	14.0±0.5	0.7
Fe_2O_3	85	90	7.0±0.8	15.0±0,8	0.7
Al_2O_3	60	80	4.5±0.5	7.0±0.1	0.6

Table 2. The effect of nanoparticles on the content of photosynthetic pigments in wheat leaves (mg / g wet weight)

Options	Chlorophyll a +b	a/b	Carotenoids
Control	2.35±0,11	3.27	4.5±0.2
CuO	1.86±0,13	3.04	5.8±0.5
TiO_2	2.61±0,34	3.67	6.4 0,3
ZnO	2.59±0,25	3.75	7.2±0.4
Fe_2O_3	2.82±0,14	3.91	7.4±0.3
Al_2O_3	2.51±0,12	3.11	7.8±0.2

This increases the content of gluten in grain, oil in seeds and amino acids in the leafy mass of forage crops. It had shown that iron nano compounds have different effects on the content of photosynthetic pigments *Triticum vulgare* (Lebedev et al., 2014). The total amount of photosynthetic pigments greatly influenced by Fe_3O_4 nano compounds compared to FeO. In these works, shown that the degree of influence of nano compounds on the content of photosynthetic pigments depends on their concentrations.

CONCLUSION

Nano compounds of TiO_2, ZnO and Fe_2O_3 had a positive effect on seed germination and accelerated the growth of wheat seedlings. ZnO and Fe_2O_3 nano compounds also positively influenced the activity of photosystem 2, where photo oxidation of water occurs with the release of hydrogen and molecular oxygen protons.

REFERENCES

Astafurova T.P. et al. (2011) The effect of titanium dioxide and alumina nanoparticles on morphophysiological parameters of plants. *Bulletin of Tomsk State University, ser. Biology*, **1(13):** 113–122 (in Russian).

Fedorenko V.F. et al. (2011) Nanotechnology and nanomaterials in the agricultural sector. M., 312 p. (in Russian).

Kovalenko L.V., Folmanis G.E. (2006) Biologically active nanopowders of iron. M.: Science, 124 p. (in Russian).

Kuamri M. et al. (2012) Effect of silver nanoparticle (SNPs) on protein and DNA content to tomato seed (*L. esculentum*), cucumber (*Cucumis sativus*) and maize (*Zea mays*). *IJHGMBMS*, **1(1):** 7–15.

Lebedev S.V., Korotkova A.M., Osipova E.A. (2014) Evaluation of Fe iron nanoparticles, magnetic Fe_3O_4 and $FeSO_4$ iron sulfate for the content of photosynthetic pigments *Triticum vulgare*. *Russian Journal of Plant Physiology*, **61 (4):** 603-607 (in Russian).

Morgalev Yu.N. (2010) Biological testing of nanomaterials: on the possibility of translocation of nanoparticles into food networks. *Russian Nanotechnologies*, **5(11-12):** 131-135 (in Russian).

Omelchenko A.V. et al. (2014) The stimulating effect of silver nanoparticles on the growth and development of wheat plants. *Uchenye Zapiski Tavricheskogo National University Series "Biology, Chemistry"*, **27(66)(No. 1):** 127–135 (in Russian).

Salama H. (2012) Effects of silver nanoparticles in some crop plants, Common bean (*Phaseolus vulgaris* L.) and corn (*Zea mays* L.). *J. Biotechnology*, **3(10):** 190–197.

Shlyk A.A. (1971) Determination of chlorophylls and carotenoids in extracts of green foxes. *Biochemical methods in plant physiology* (M.: Nauka), p. 154-170 (in Russian).

Torre-Roche R.De la. (2013) Impact of Ag nanoparticle exposure on p,p′-DDE bioaccumulation by *Cucurbita pepo* (zucchini) and *Glycine max* (soybean). *Environ. Sci. Technol*., **47:** 718–725.

Yegorov N.I. et al. (2008) Development and conduct of an experimental evaluation of the effectiveness of the use of new types of fertilizers in crop production using nanotechnology. *Bulletin of the Nizhny Novgorod University,* **6:** 94–99.

Yurin V.M., Molchan O.V. (2015) Nanomaterials and plants: a look at the problem. *Proceedings of the BSU*, **10(1):** 9-21 (in Russian).

Yurkova I.N. et al. (2014) The influence of silver nanoparticles on the growth processes of wheat. *Bulletin of VSGUTU*, **1:** 69–73 (in Russian).

Zhu H. et al. (2008) Uptake, translocation and accumulation of manufactured iron oxide nanoparticles by pumpkin plants. *Journal Environment Monitoring*, **10:** 713–717.

Nano birləşmələrinin buğda cücərtilərinin fizioloji xüsusiyyətlərinə təsiri

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Mis, titan, dəmir, və alüminium oksidləri nano birləşmələrinin buğda toxumlarının cücərmə enerjisinə, cücərmə faizinə, cücərtilərin böyümə və inkişafına, fotosintez piqmentlərinin miqdarına və fotosistem 2-nin fəallığına təsiri öyrənilmişdir. Tədqiqat obyekti kimi yumşaq buğda (Triticum aestivum L.) cücərtilərindən istifadə edilmişdir. Buğda toxumları CuO, Fe_2O_3, ZnO, Al_2O_3 və TiO_2 nanobirləşmələrinin tozları ilə işlənilərək Peter nimşələrində və dibçəklərdə torpaq mühitində əkilmişdir.Toxumların cücərmə enerjisi, cücərmə faizi, cücərtilərdə xlorofil a və b-nin miqdarı, fotosistm 2- nin fəallığı ölçülmüşdür. TiO_2,, ZnO və Fe_2O_3 nano birləşmşləri toumların cücərməsinə və cücərtilərin böyüməsinə stimullaşdırıcı təsir göstərmişlər. ZnO и Fe_2O_3 nano birləşmələri həmçinin fotosistem 2-n fəallığına müsbət təsir göstərərək suyun fotooksidləşməsini, hidrogen protonlarının və molekulyar oksigenin ayrılmasını sürətləndirmişlər.

***Açar sözlər**: Buğda, nano birləşmələr, cücərmə, cücərtilərin böyüməsi, fotosistem 2*